Indicator: Blood Lead Level and Childhood Blood Lead (098 and 105)

Lead is a naturally occurring metal found in small amounts in rock and soil. Lead has been used industrially in the production of gasoline, ceramic products, paints, and solder. While lead arising from the combustion of leaded gasoline was a major source of exposure in past decades, today lead based paint and lead-contaminated dust from paint are the primary sources of lead exposure in the home. Lead levels can be measured in blood or urine.

Lead is a neurotoxic metal that affects areas of the brain that regulate behavior and nerve cell developments (NRC, 1993). Its adverse effects range from subtle responses to overt toxicity, depending on how much lead is taken into the body and the age and health status of the person (CDC, 1991). Lead is one of the few pollutants for which biomonitoring and health effect data are sufficient to clearly evaluate environmental management efforts to reduce lead in the environment.

Infants, children, and fetuses are more vulnerable to the effects of lead because the blood-brain barrier is not fully developed (Nadakavukaren, 2000). Thus, a smaller amount of lead will have a greater effect in children than in adults. In addition, ingested lead is more readily absorbed into a child's bloodstream, while adults absorb only 10%. Because of lead's adverse effects on cognitive development, CDC has defined an elevated blood lead level as equal to or greater than 10 micrograms/deciliter (µg/dL) for children under 6 years of age (CDC, 2003).

This indicator is based on data collected by the National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

The overall geometric mean for blood lead levels among all participants aged 1 year and older from NHANES 1999-2000 was 1.7 µg/dL (Table 098_105Lead). Adults aged 20 years and older had a geometric mean lead level of 1.8 µg/dL. Males and females had a geometric mean lead level of 2.0 µg/dL and 1.4 µg/dL, respectively. For non-Hispanic African-Americans, Mexican Americans, and non-Hispanic Whites the geometric mean lead levels were 1.9, 1.8, and 1.6µg/dL, respectively.

Of all groups, children aged 1-5 years had the highest geometric mean lead level at 2.2 µg/dL. Children aged 6-11 years and teenagers aged 12-19 years geometric mean lead levels were 1.5 and 1.1 µg/dL, respectively.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representativeness of coverage.

- The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- The measurement of lead or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Source

Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Last Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

References

Centers for Disease Control and Prevention (CDC). 1991. Preventing lead poisoning in young children. U.S. Department of Health and Human Services, Public Health Service. (Last Accessed November 21, 2004) http://aepo-xdv-www.epo.cdc.gov/wonder/prevguid/p0000029/p0000029.asp

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Last Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Nadakavukaren A. 2000. Our Global Environment: A Health Perspective, Fifth Edition. Prospect Heights, IL: Waveland Press, Inc.

National Research Council. 1993. Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations. Washington, DC: National Academies Press.

Graphics

Table 098_105Lead. Geometric mean and selected percentiles of total blood lead concentrations (in µg/dL) for the United States population, aged one year and older, by select demographic groups, National Health and Nutrition Examination Survey (NHANES), 1999-2000.

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
Total, Age 1 year and older	7,970	1.7	0.8	1.0	1.6	2.4	3.8
Sex							
Male	3,913	2.0	0.8	1.3	1.8	2.9	4.4
Female	4,057	1.4	0.6	0.8	1.3	1.9	3.0
Race Ethnicity*							
Black, non-Hispanic	1,842	1.9	0.7	1.1	1.7	2.8	4.2
Mexican American	2,743	1.8	0.8	1.2	1.8	2.7	4.2
White, non-Hispanic	2,715	1.6	0.6	1.0	1.6	2.4	3.6
Age Group							
1-5 years	723	2.2	1.0	1.4	2.2	3.3	4.8
6-11 years	905	1.5	0.7	0.9	1.3	2.0	3.3
12-19 years	2,135	1.1	0.4	0.8	1.0	1.4	2.3
20+ years	4,207	1.8	0.7	1.0	1.7	2.5	3.9

*Other racial/ethnic groups are included in the Total only

Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD LEAD LEVEL
Indicator Number: 098 (89122)
Data Set Source: NHANES 1999-2000
Data Collection Date: ongoing
Data Collection Frequency: 2 yr cycle
Data Set Description: Blood Lead Level (including childhood blood lead - combines 098 & 105)
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf Cadmium and lead were simultaneously measured in whole blood. Cadmium and lead quantification is based on the measurement of light absorbed at 228.8 nm and 283.3 nm, respectively, by ground state atoms of cadmium and lead from either an electrodeless discharge lamp (EDL) or hollow cathode lamp (HCL) source. Human blood (patient or study) samples, bovine blood quality control pools, and aqueous standards are diluted with a matrix modifier (nitric acid, Triton X-100, and ammonium phosphate). The cadmium and lead contents are determined on a Perkin-Elmer Model SIMAA 6000 simultaneous multi-element atomic absorption spectrometer with Zeeman Background correction. See: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The units used for this indicator were ¼g/dL. http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. All participants aged 1 year or older in NHANES 1999-2000 were measured for blood lead. The measurements produced by NHANES for this indicator were used in the “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable. The indicator is a direct measure of lead in blood.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a

continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to lead has occurred. Blood lead measurement is the preferred method (over urinary measurements) of evaluating lead exposure and its health effects in people. Blood lead levels (BLLs) are contributed to by both recent intake and an equilibration with stored lead in other tissues, whereas urine lead levels result from only recent exposures. The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) requires monitoring of blood lead and reduction of exposure to lead when worker BLLs are higher than 40 ¼g/dL of whole blood. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that BLLs in workers not exceed 30 ¼g/dL. The Deutsche Forschungsgemeinschaft provides a Biological Tolerance Level of 40 ¼g/dL for workers. The World Health Organization has a level of concern of 20 ¼g/dL. The CDC recommends that children's levels not exceed 10 ¼g/dL. As reported in "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf The measurement of lead or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf Laboratory measurement information: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf And the "Weighting Notes" posted on the NHANES website also offer helpful advice. http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues.
http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES

sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value. For more information, see the addendum to NHANES III linked below: http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. Lead was measured in the 2001-2002 cycle and the current 2003-2004 cycle. Effort will be made to include in this report any published updates. http://www.cdc.gov/exposurereport/pdf/third_report_chemicals.pdf Serum lead was measured in all people in the survey year aged one year and older. The measurement of lead or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.